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Groundwater – An Important Rural Resource

UNDERSTANDING GROUNDWATER

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All Ontarians can play a role in protecting groundwater quality and quantity. This Factsheet is the first of four in a series that will help Ontario's farmers and rural residents learn more about groundwater – what conditions affect its presence, movement and quality, how to protect this largely invisible resource subsurface, and why some subsurface materials are a better source of water than others.

Other Factsheets in this series include:

- *Managing the Quantity of Groundwater Supplies* (Order No. 06-113)
- *Protecting the Quality of Groundwater Supplies* (Order No. 06-115)
- *Private Rural Water Supplies* (Order No. 06-117)

A reliable supply of clean water is essential to the health of Ontarians and to the health of rural businesses – especially farming businesses. In Ontario, most rural homes and businesses, and 23% of the broader population, depend on groundwater for their water supply. In some areas, groundwater may be the only source of water.

Water is always on the move. This Factsheet explains where groundwater comes from, how it is replenished, how it moves in the subsurface and why some subsurface materials are a better source of water than others. Groundwater terms and concepts such as "aquifer," "aquitard," "porosity," "formations," and "permeability" are explained. Subsequent Factsheets explore how each of these can affect the integrity of well water and provide tips to minimize the risk of contamination.

THE WATER CYCLE

Water is continually moving from one location to another and even changes from one form to another — from vapour to liquid, from liquid to solid and then back to liquid or vapour. Water's endless journey takes a series of pathways called the hydrologic cycle, also called the water cycle (see Figure 1, next page). Rain (or melting snow) at the surface can take several paths. It can run off over land into surface water bodies such as streams or lakes. It can seep (infiltrate) into the ground to be used directly by plants or to recharge groundwater. It can evaporate from the ground or surface water bodies, or be released by plants (transpiration) to return to the atmosphere in a process called evapotranspiration. The cycle is complete when water in the atmosphere returns to the land as rain or snow.

Groundwater is water that seeps into the ground and passes through subsurface materials such as bedrock and sediments. Eventually it reaches a spring, stream, lake or wetland, where it discharges to the surface, becoming surface water.

WATER IN THE GROUND

Groundwater is found in and moves through subsurface materials. Near the surface, there are different types of bedrock, such as granite, shale, sandstone and limestone. In many areas, the bedrock is covered with deposits of sediments, including clay, silt, sand or gravel. A layer of bedrock or sediment that consists primarily of a certain type (or combination of types) of geological material is called a "formation."

Formations contain pores or small openings. The percentage of the total volume of pore space in rock or sediment is called its "porosity." The greater the porosity, the greater the amount of water that can be held by a formation. For example, sand and gravel formations can have a porosity percentage as high as 25%–50%, while some dense, solid bedrock may be less than 0.1%.

Different formations have different degrees of porosity. The greater the porosity, the greater the amount of water the formation can contain.

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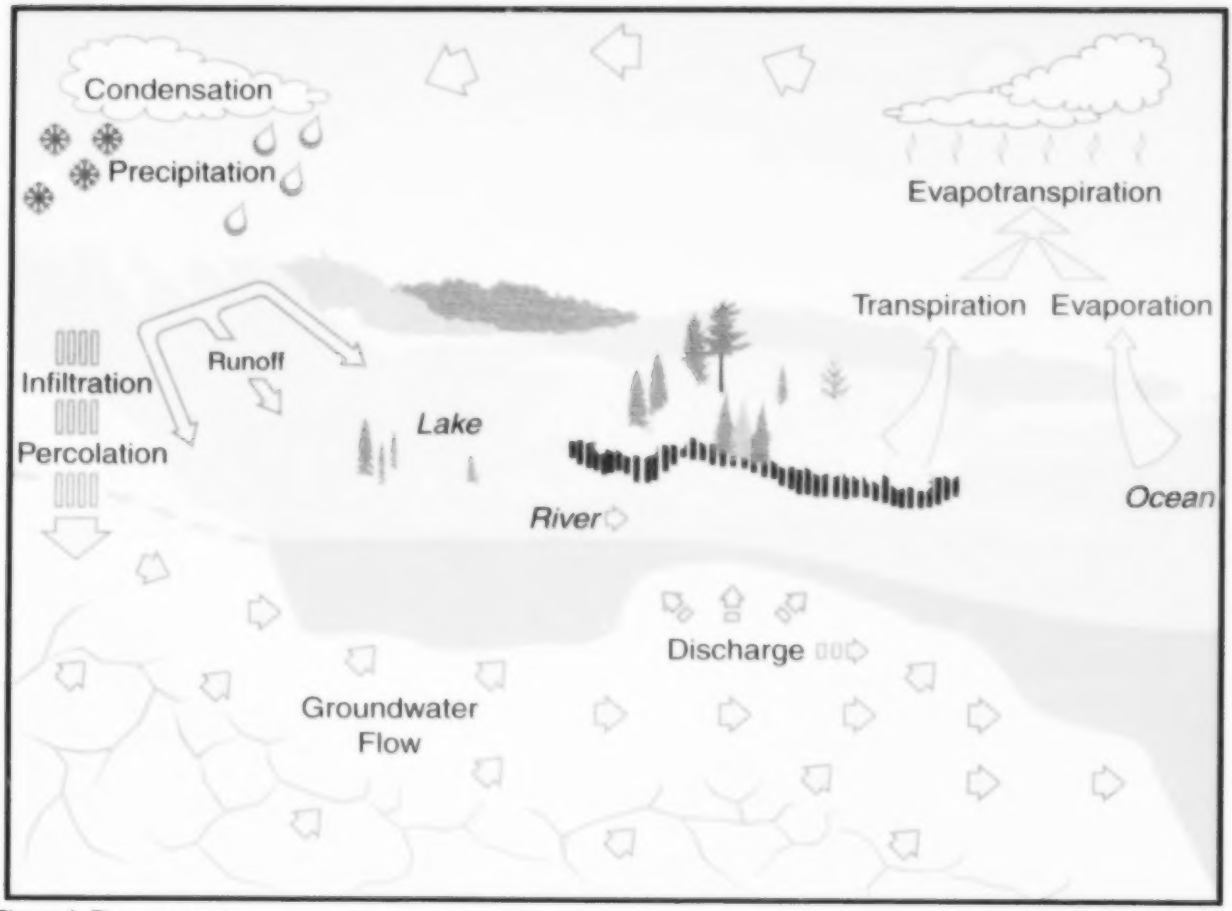

Figure 1. The water cycle.

The rate that water can move through a formation (slow to rapid) depends on its porosity and, more importantly, on how well the pores are connected. For instance, water moves quickly through formations with many large connected pores, such as gravel or highly fractured bedrock. Water moves slowly through formations with small, poorly connected pores such as clay. Formations that allow water to flow easily and quickly, such as sand and gravel deposits or sandstone, are called highly permeable. By contrast, clay, silt and solid granite formations are much less permeable (see Figure 2, right).

Near the ground surface, pores usually contain a mixture of air and water — in water terms, they are considered unsaturated. At greater depths, the pores will become full of water or continuously saturated. The water table is defined as the level in the ground above which pores are unsaturated, and below which pores are saturated.

Over time, the water table moves up and down with seasonal changes in rainfall, evapotranspiration and pumping of wells. All wells draw their water from below the water table.

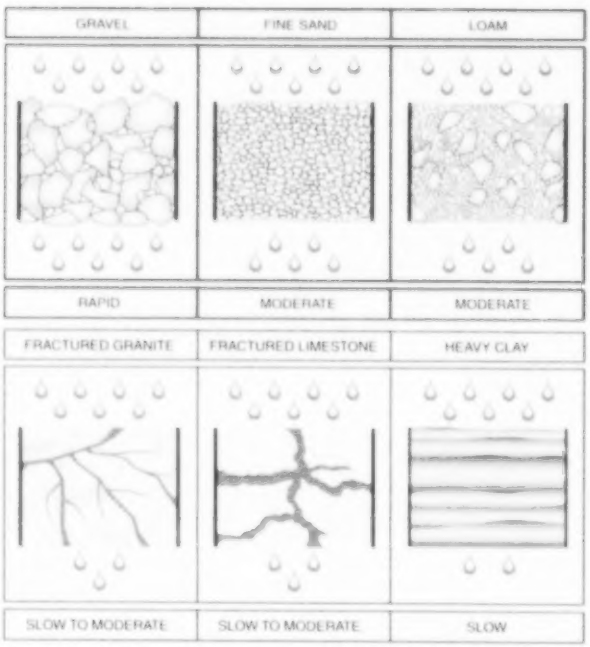

Figure 2. Water moves and is contained at different rates through various geological materials.

Pumping a well changes the amount and direction of movement of groundwater within the subsurface. This concept is explored in more detail in the OMAFRA Factsheet *Managing the Quantity of Groundwater Supplies* (Order No. 06-113).

AQUIFERS AND AQUITARDS

An aquifer is a permeable, saturated formation that will yield useful amounts of water when pumped. The most productive aquifers, such as sands and gravels, are typically thick and large in area and are replenished or recharged by infiltrating rainwater. Other formations, called aquitards (or confining layers), are made up of materials with low permeability, such as layers of clay and shale, which prevent any significant movement of water.

> Contrary to popular belief, groundwater does not flow in underground rivers.

There are three main types of aquifers:

- Unconfined aquifers (or water table aquifers) are ones where the top of the aquifer is also the water table.
- Confined aquifers occur where the permeable formation is located below an aquitard or confined between two aquitards.
- A semi-confined aquifer or "leaky" aquifer is similar to a confined aquifer, except that the aquitards next to it are more permeable and let significant amounts of water move through to the aquifer.

Unconfined aquifers are often the shallowest and most easily accessed, whereas confined and semi-confined aquifers are often found at greater depths. The greater the depth and amount of material overlying a semi-confined or confined aquifer, the less prone it, and the groundwater it contains, is to contamination. The importance of this is discussed in the OMAFRA Factsheet *Protecting the Quality of Groundwater Supplies* (Order No. 06-115).

Figure 3, right, illustrates examples of different aquifers. For unconfined aquifers, the water table is also the top of the aquifer. A confined aquifer occurs where the permeable formation is located below an aquitard or confined between two aquitards as shown. A semi-confined or leaky aquifer (not shown) is the same as a confined aquifer, except that one of the aquitards is more permeable and lets significant amounts of water move through it into the aquifer.

HOW GROUNDWATER FLOWS

Water infiltrates below ground and recharges groundwater most readily in areas where permeable deposits are found at the ground surface. Once in the aquifer, the permeability, porosity and other factors will determine how fast the groundwater moves.

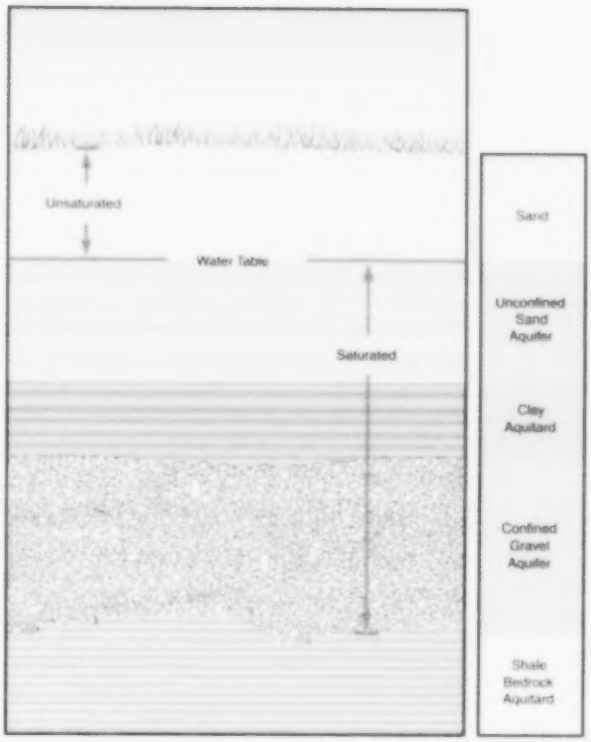

Figure 3. Subsurface view of various aquifers.

Groundwater can flow a few centimetres to a few metres a day in sand or gravel aquifers, and even tens of metres a day (fast) or more in some highly fractured bedrock aquifers. In some aquitards, the water may move less than a few millimetres in a day (slow).

In general, groundwater moves from areas of recharge toward areas of discharge such as springs, streams, lakes or wetlands, etc. Water infiltrating or recharging in the hills or uplands of a river valley travels down to the water table aquifer, then moves horizontally through the various formations until it reaches the river, where it will discharge up through the riverbed (see Figure 4, next page).

The exact path that the water flows along can be complex, but most of the water will take the path of least resistance, flowing through the most permeable formations. Some recharged water can also flow downward through unconfined aquifers to recharge deeper confined aquifers. Eventually it flows to discharge locations as far as several kilometres away.

RECHARGE AREAS

Recharge areas infiltrate a significant amount of water into the subsurface. Sometimes these areas are concentrated, covering a small part of the total land area. For instance, where there are large sand and gravel deposits, 20% of the land area infiltrates 80% of groundwater. In other places with flat landscape or low-permeability soils, a small amount of infiltration may take place over a large area.

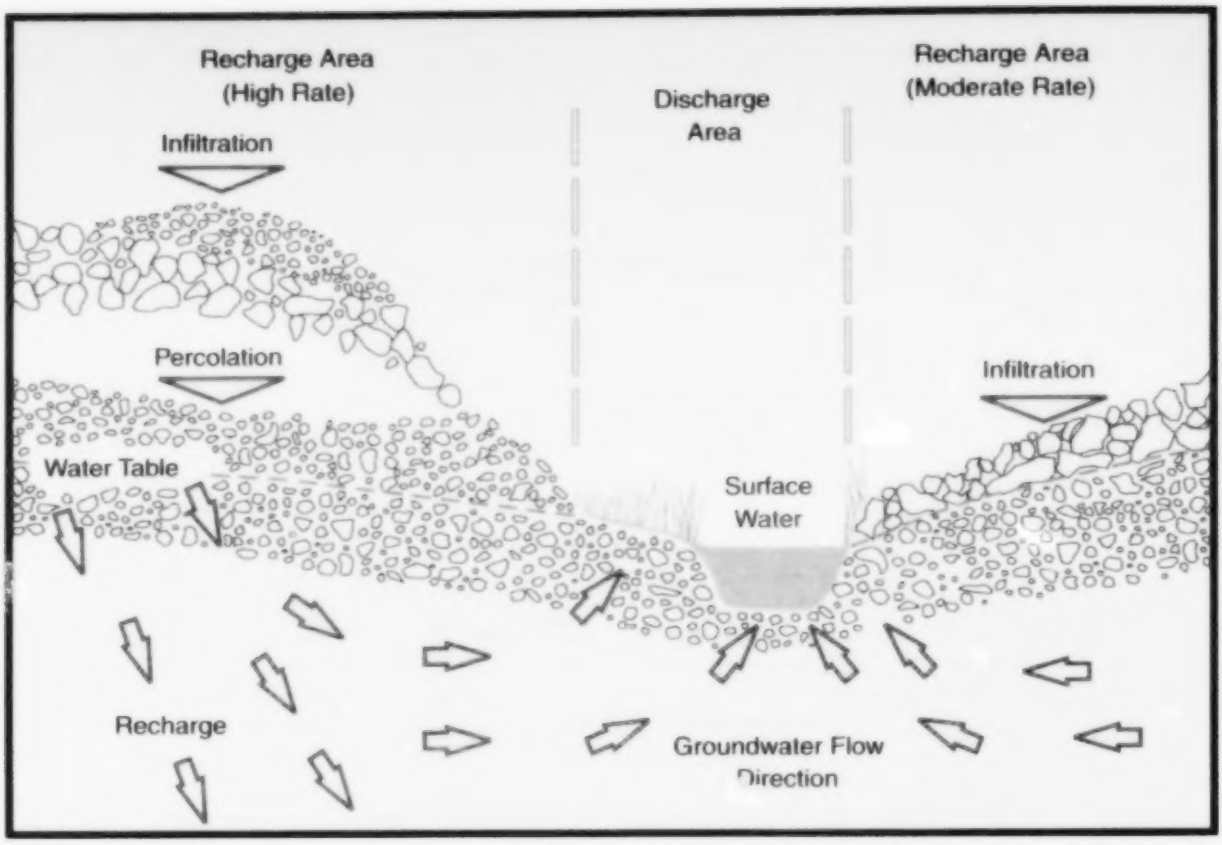

Figure 4. Groundwater flows downwards and away from recharge areas to deeper aquifers and to surface water discharge areas.

RATE OF GROUNDWATER RECHARGE (AGE OF WATER)

The age of water refers to how long it takes for water to move from the ground surface to a particular point below the ground. Scientists use several methods to find out which way groundwater is moving, how fast it is moving and its age.

With shallower wells in permeable unconfined aquifers, the age of water may be measured in only weeks or months. By comparison, the age of water in water wells constructed in confined aquifers is measured in years — sometimes hundreds of years.

The importance of water's age in protecting individual water wells is explained in more detail in the OMAFRA Factsheet, *Private Rural Water Supplies* (Order No. 06-117).

OTHER SOURCES OF INFORMATION

OMAFRA. *Best Management Practices: Water Wells*, Order No. BMP 12.

Ontario Ministry of the Environment. *Well Aware – A Well Owner's Guide* (videotape).

Ontario Ministry of Health and Long-Term Care. *Keeping Your Well Water Safe to Drink: An Information Kit to Help You Care for Your Well*, BMP 12K.

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